

Guidelines for Increasing Urea Utilization in Rations for Dairy Cows

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INTRODUCTION

Since 1879 when Weiske et al (24) discovered that sheep could use amide nitrogen, an extensive amount of research has been directed toward the utilization of urea in the ruminant (21). An important contribution in this country was the research of Hart and associates (12) who showed the need for readily fermentable carbohydrates when urea was fed. Partly as a result of this early work, the feed-urea industry has been growing rapidly for a quarter of a century. This growth is expected to continue.

The most encouraging developments with respect to non-protein nitrogen (NPN) utilization are occurring on the dairy farms of North America. Urea in particular is being used in increasing amounts. This increase in urea feeding is due to: 1) the economic advantage of replacing the usually more expensive sources of nitrogen with urea, 2) the necessity brought about by a demand for feed nitrogen which has grown at a faster rate than the natural supply of supplemental protein, 3) increased acceptance by farmers of urea usage in feeds, and 4) improved technology for methods of using urea in feeds.

Further opportunities for using additional amounts of urea must come from introducing into feed practices new concepts developed in the last decade and diligently applying some facts which have been known for some time. There is considerable question whether the thumb rule for using urea at "3% of concentrate or 1% of dry matter" is in line with the response which can be expected from high-producing cows and in relation to the amounts of feed they consume.

The basis for a new approach was first reported in 1944 at the annual meeting of the American Dairy Science Association at Columbus, Ohio. T. E. Woodward and J. B. Shepherd (26) stated: "Small silos were filled with corn and heavier additions of urea. A Holstein cow ate in 61 days an average of 104 lb. of silage a day containing 1.17 lb. of urea. A Jersey cow ate in 60 days an average of 58 lb. containing 0.58 lb. of urea. Post mortem examination revealed no evidence of harm to either cow." The work of Woodward and Shepherd (26) failed to catch on, apparently because they were unable to show an advantage for adding urea to corn silage.

TABLE 1.—The Amount of Urea to Add to Freshly Chopped Corn at Different Moisture Contents.

Percent Dry Matter in Silage Corn	Amount of Urea
	(Lb /Ton)
27 (early dent)	8
33 (glaze)	10
50 (mature-post frost)	15

DISCUSSION

Urea-Treated Corn Silage

There is presently much interest in the practice of adding urea to chopped corn at time of ensiling. This method has been found to be a safe and convenient way to mix urea into dairy cattle rations, although some losses can be expected.

In three batches of urea-treated corn silage fed in 1966 at OARDC, it was found that loss of nitrogen ranged between 0 and 18% of the total nitrogen. The average loss was 11%. This compares to an average of 10% loss in several studies conducted at other research institutions. As the dry matter content of the silage increased, the losses increased. Cost of this may be considered acceptable by most farm operators when the labor saving, convenience, and safe mixing of urea afforded by this method are considered.

The amount of urea commonly added to corn silage (32% dry matter) is 10 lb. per ton. This amount may be increased for drier mature corn harvested after the plants are frosted. Suggested amounts are presented in Table 1.

In a recent experiment, corn silage (32% dry matter) with 20 lb. of urea added per ton was fed without adverse physiological effect to 30 cows. It was found that 20 lb. of urea per ton of 32% dry matter corn silage was sufficient supplemental nitrogen to maintain milk pro-

TABLE 2.—Typical Results When a 1400-Lb. Holstein Was Fed Corn Silage Containing 0, 10, 20, and 30 Lb. of Urea Added per Ton of Freshly Chopped Material.

Urea Additions		Digestible Dry Matter Intake	Milk Production
In Grain	In Corn Silage		
(%)	(Lb /Ton)	(Lb /Day)	(Lb /Day)
3	0	33.9	66.9
1 ½	10	32.9	67.7
0	20	34.6	65.2
0	30	29.3	56.5

duction at an average of 48 lb. (3.5% milk fat) during the third to sixth month of lactation. Based on performance in previous lactations and during the preliminary period, it was concluded that the cows were producing at an average of 2 to 4 lb. below their expected level of production. Thus, with this experimental ration composed entirely of corn silage plus urea and cereal grain with dicalcium phosphate supplement, highly satisfactory but not maximum yields were obtained.

In digestibility trials, dry matter digestibility of the total ration was only 68.3%. For high-producing cows, this level of digestibility was too low to support milk production equal to the initial yield at the time the cows were started on the experiment. To do this would have required a dry matter digestibility higher than 70%.

Thirty pounds of urea added per ton of corn silage resulted in too much urea nitrogen to maintain feed intake and milk yield in four cows which were fed in sequence batches of silages containing 0, 10, 20, and 30 lb. of urea per ton of freshly chopped corn added at ensiling. The data in Table 2 show depressed feed intake at the 30 lb. per ton level in the highest producing cow.

On the basis of the overall results, it appears that up to 20 lb. of urea per ton could be added safely to corn silage for dairy cows provided this is fed in a ration in which 50% of the total dry matter is cereal grain to provide the needed energy for efficient urea utilization. The high level of grain required with the 20 lb. level makes that amount of urea somewhat impractical to feed throughout a lactation period.

The limits of tolerance for NPN may be reached if urea-treated corn silage is the only roughage fed free choice and the amount eaten is relatively large. This is the first major limitation to be considered.

These limits were estimated from studies on feed intake, milk production, and nitrogen balance trials during a period in which increasing levels of urea were fed. It was found that 0.4 to 0.5 lb. of NPN in the feed per 1,000 lb. of body weight resulted in decreased feed intake and lowered milk production. Table 3 may be used as a guide to calculate the NPN consumed in corn silage of different dry matter content when either 10 or 20 lb. of urea are added per ton.

Composition of Urea Diets

The success of urea feeding is dependent on the amount and composition of the carbohydrates fed. This is the second important practical consideration.

Effects of various carbohydrates on urea utilization have been the subject of *in vitro* studies in many countries of the world (1, 2, 18, 19, 25). These *in vitro* studies, coupled with animal experiments on calf

TABLE 3.—Pounds of Non-Protein Nitrogen Consumed Daily at Various Levels of Corn Silage Intake.

Dry Matter in Silage	Urea Added	Amount of Silage Eaten Daily			
		25	50	75	100
(%)	(Lb./Ton)			(Lb.)	
28	10	0.10	0.22	0.32	0.42*
	20	0.15	0.33	0.48*	0.63*
32	10	0.11	0.23	0.34	0.45*
	20	0.16	0.34	0.50*	0.66*
40	10	0.13	0.26	0.39	0.51*
	20	0.18	0.37	0.55*	0.72*
48	10	0.14	0.29	0.43*	0.55*
	20	0.19	0.40*	0.59*	0.76*

*Level at which feed intake may be reduced in a 1,000-lb. cow.

and heifer growth (3, 12, 14, 23), milk production (16, 20, 22, 24), and nitrogen balance (5, 6, 11, 15, 17), are the basis for prescribing the quantity of carbohydrates needed for maximum utilization of NPN in dairy cows. The quantity needed approximates 10 lb. of readily fermentable carbohydrates per lb. of urea in an adapted cow. Urea level in the diet therefore is not restricted by a fixed percent but can be fed as a function of the energy level.

About two-thirds of the readily fermentable carbohydrates should be starch. The proportion of cereal grain (the chief source of starch) in the feed cannot be reduced very much without a proportionate drop in milk production from having decreased the fermentable carbohydrates. In practice, this means that cows need 24 to 30 lb. of grain daily to utilize 1 lb. of urea. They then convert 30 to 33% of that nitrogen into milk protein nitrogen.

The total quantity of feed consumed is equally important to the cow in determining the amount of nitrogen used. Nitrogen utilization was found to be a linear function of digestible energy input regardless of body weight of the cattle used (Figure 1).

The pathway for utilization of NPN is via rumen microorganisms. As microorganisms multiply, they synthesize protein as constituents of their own cells from nutrients which are available in the rumen. Ammonia, the usual end product of urea hydrolyses, is the preferred source of nitrogen for the majority of rumen bacteria and is efficiently used for protein synthesis if conditions are favorable for maximal continuous fermentation.

Among the essential minerals, phosphorus and sulfur are apparently needed in largest amounts for optimal utilization of urea and other

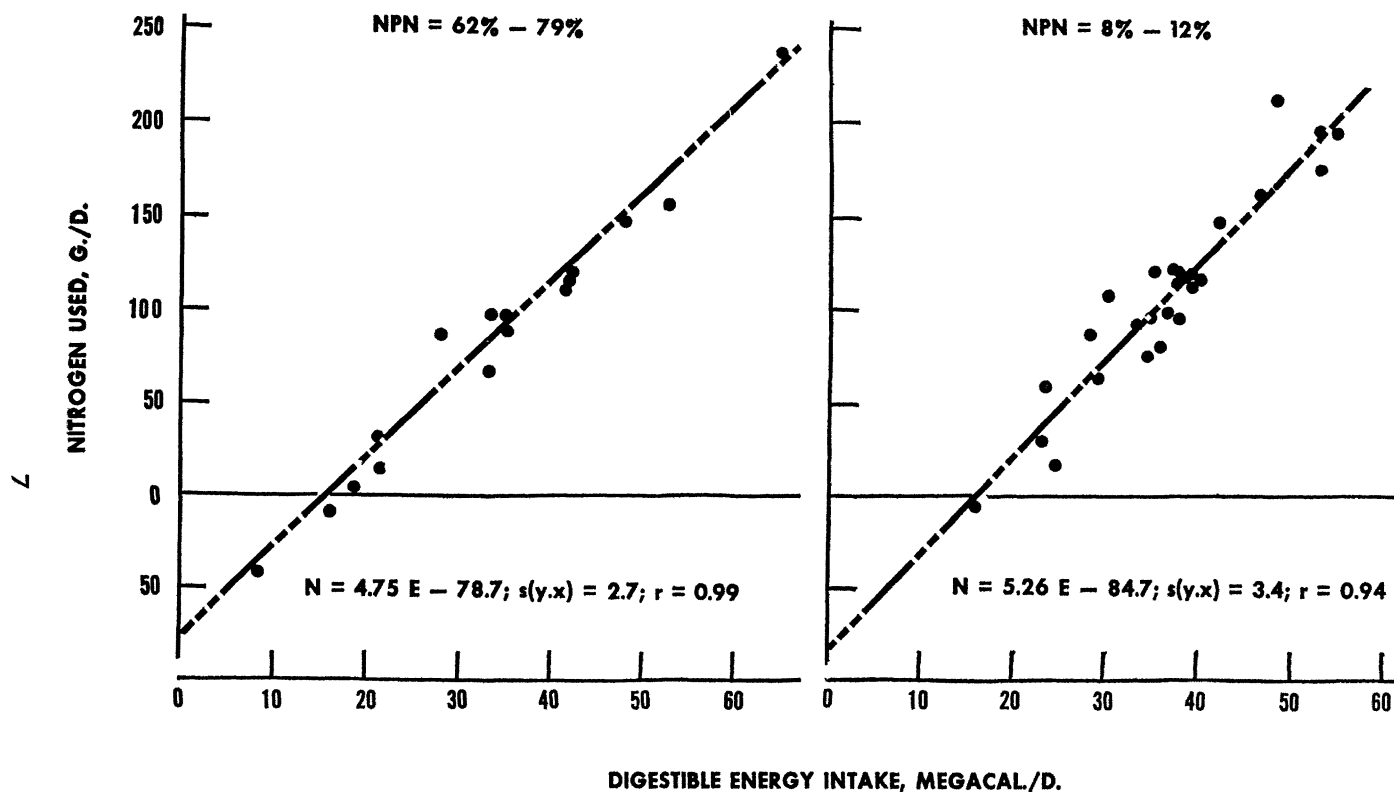


Fig. 1.—The amount of nitrogen used by dairy cows fed different proportions of NPN varied in a positive linear manner with increasing energy intake. Two nitrogen balances obtained with the same diet were averaged to obtain each point on the graph. Corn si-

lage, corn meal, oats, urea, and mineral mixtures were used in rations containing 62-79% of dietary nitrogen as NPN. Legume-grass hay, soybean meal, flaked soybean hulls, corn meal, and oats were used in rations containing 8-12% of dietary nitrogen as NPN.

sources of NPN (4). A highly successful mineral mixture currently used by Virtanen (22) to meet the needs of the rumen microorganisms and the cows on purified diets also contains sodium, potassium, calcium, magnesium, copper, selenium, boron, cobalt, iodine, and molybdenum.

Adaptation

Cows may need some time to adapt to rations containing urea and other sources of NPN. During the course of several sheep and steer metabolism trials with purified type diets containing urea and other NPN sources, adaptation occurred over periods of 50 days or more. Adaptation was apparently prolonged in these animals

Diminished response may be expected if cows are started abruptly on high-urea rations during periods of negative nitrogen balance, particularly during the first 21 days of the lactation when feed intake may be low.

A 2-week changeover period has been found to be satisfactory. This is the third important practical consideration.

Maximum Capability for Non-Protein Nitrogen Utilization

In the current study using the results from 86 nitrogen balance trials, it was concluded that sources of nitrogen varying widely in the ratio of protein to NPN had only small effects on amount of nitrogen used (Figure 1). If the energy was consumed, the nitrogen was used. Changes in nitrogen used per megacalorie (therm) of digestible energy eaten supported the conclusion previously discussed that the prime effect of NPN on overall nitrogen status is elicited through a limiting action on feed intake.

An average of 5.0 g of nitrogen used per megacalorie of digestible energy consumed is equivalent to 31 g of protein per megacalorie (Figure 1). The ratio built into the recommended daily allowance for dairy cows is 38 to 40 g. of digestible protein per megacalorie of digestible energy (13). The difference is excreted in the urine.

High-producing cows fed rations containing all plant proteins as sources of nitrogen converted a maximum of 41% and an average of 32% of total feed nitrogen to milk and tissue nitrogen (7, 9). In the case of high-urea, high-grain concentrates, the overall efficiency ranged between 29% and 32% utilization of the feed nitrogen consumed (8).

Limiting NPN utilization is a function of the amount of digestible organic matter available in the rumen. Thus, there is a close linkage between fermentation rate, growth rate of rumen microorganisms, bacterial protein synthesized, and the energy yielding material fermented.

Thus the amount of protein synthesized is set by the amount of energy yielding material present in the rumen. In applied terms, 10.2% of

the digestible organic matter eaten is converted to microbial protein. This is the fourth major consideration in establishing how much urea may be used in successful rations for dairy cows.

Since the capacity of the rumen to convert ammonia nitrogen to protein is limited to about 10% of the digestible organic matter in the fermentation process, a 1400-lb. cow eating 50 lb. of feed daily will have approximately 3.5 lb. of ruminally synthesized protein available for digestion. The remainder of her needs, which could be an additional 3.5 lb. if she were producing 75 lb. of milk, must be digested from ruminally by-passed preformed protein.

Pelleting Urea with Alfalfa Meal (Dehy-100) Increased Acceptability

It has been observed that cows will eat a concentrate mixture containing 1% urea without much hesitance. Similarly, most concentrate mixtures fed to dairy cows will cover up the urea taste sufficiently so that 2% urea may be used.

By pelleting with alfalfa, the quantity of urea contacting the taste buds of the mouth is reduced. Thus, the fifth major consideration in feeding high-urea rations is to employ some practical means of reducing the amount of unpalatable urea available for tasting in the mouth.

In preliminary OARDC research, feed intake of high-producing cows was depressed when high levels of urea were fed in the usual mixtures (2.75% of the grain concentrate or in excess of 25 to 32% of the total nitrogen). It was found that by pelleting the urea with alfalfa meal, the depression in feed intake caused by high-urea rations could be overcome sufficiently to allow maximum milk yields.

The pelleted combination of alfalfa meal and urea has provided a highly effective means of extending the quantity of urea which may be included in the rations of high-producing cows from approximately 20 to 40% of the total dietary nitrogen.

In recent Ohio studies, a pelleted combination of 66% dehydrated alfalfa, 31.6% urea, 2% dicalcium phosphate, and 0.6% sodium sulfate and 0.4% sodium propionate (a preservative) was used as the protein concentrate in the rations of high-producing cows. This protein supplement was called Dehy-100 because its crude protein equivalent was approximately 100%.

When added to corn meal and ground oats at the 9% level, it resulted in a concentrate ration containing 18 to 19% crude protein equivalent. The resulting concentrate contained just under 3% urea. It appears that the urea contained in the "Dehy" pellet is tasted to a lesser degree as it passes through the mouth. Also, the fact that the urea is in close proximity to the alfalfa particle may contribute to the increased use of urea for protein synthesis.

All of the cows fed Dehy-100 as the only supplemental protein concentrate produced exceedingly well. Milk yields of cows fed Dehy-100 were equal to those receiving soybean meal as the protein supplement (Table 4). They consumed a maximum of 1 lb. of urea and 2 lb. of dehydrated alfalfa daily in the form of Dehy-100. It is pointed out that 35 to 40% of the total nitrogen eaten by these cows was urea nitrogen. The concentrates fed were Dehy-100 (10%) or soybean meal (22%), ground corn and oats, 2% dicalcium phosphate, and salt. The

TABLE 4.—Milk Yield of Cows Fed Either Dehy-100 or Soybean Meal (SBM) as the Protein Supplement in a Concentrate Containing 3.0% Total Nitrogen or 18.8% Crude Protein Equivalent.*

Cow No.	Year	Type of Grain	Days in Milk	Total Milk for Period	Total Fat for Period	4% FCM
				(Lb)	(Lb)	(Lb)
J 1632	1966	Dehy-100	305	11,388	518 5	12,336
J 1599	1967	SBM	305	13,108	660 2	15,148
H-1361	1966	Dehy-100	232	14,469	626 8	15,195
H 1361	1967	SBM	232	14,476	575 8	14,428
H 1601	1966	SBM	305	20 439	473 0	15,276
H-1601	1967	Dehy-100	305	19,855	581 3	16,663
J-1693	1966	SBM	305	8 700	454 8	10,303
J 1693	1967	Dehy-100	305	8,023	483 7	10,470
H 1637	1966	SBM	305	18 758	559 0	15,893
H-1637	1967	Dehy-100	305	16,580	552 4	14,920
H 1724	1966	SBM	305	13,944	436 3	12,125
H 1724	1967	Dehy-100	305	16 084	528 2	14,361
H-1580	1966	Dehy-100	305	14,528	504 7	13,381
H 1580	1967	SBM	305	16 849	612 6	15 929
H 1617	1966	Dehy-100	305	17,576	576 4	15,681
H 1617	1967	SBM	305	14,227	454 9	12,554
H-1697	1966	SBM	245	14,308	550 0	13,977
H-1697	1967	Dehy-100	245	14,748	600 3	14,908
H-1529	1966	Dehy-100	262	15,086	574 0	14,645
H-1529	1967	SBM	262	16,479	603 7	15,650
H-1439	1966	SBM	305	18,795	624 0	16,879
H-1760	1967	Dehy-100	305	20,579	743 7	19,385
Av, of 11 cows		Dehy-100	289	15,356	571 8	14,722
Av of 11 cows		SBM	289	15,462	545 8	14 378

*Other dietary constituents were corn silage free choice and a limited amount of alfalfa hay. The Dehy-100 was added to the basal ground corn and oats ration at the rate of 10% of the total concentrate.

cows were fed 20 to 30 lb of grain concentrate, 40 to 60 lb of corn silage, and 4 to 6 lb. of alfalfa hay.

The highest producing cow exceeded 20,000 lb of milk in a 305-day lactation. The cows consumed a maximum of 1 lb. of urea and 2 lb of dehydrated alfalfa daily in the form of Dehy-100. The maintenance of high production in cows fed Dehy-100 demonstrates the usefulness of this product as a substitute for more costly forms of protein supplement. Monetary value of Dehy-100 in terms of its digestible protein equivalent and non-protein net energy is shown in Table 5

Problems Encountered with Urea Feeding

A field test was initiated in a 48-cow herd at the North Central Branch at Castalia to determine the effects of inserting the Dehy-100 mixture abruptly in the ration in place of soybean meal. Substitution of Dehy-100 in the grain concentrate ration was on the basis of replacing the amount of nitrogen which was present in the soybean meal fraction. The cows were divided into two groups and changed abruptly at the end of alternate 30-day feeding periods. The summary of daily milk production records showed the same average milk yield for cows fed Dehy-100 and those fed soybean meal.

The grain concentrate containing Dehy-100 was eaten regularly without any noticeable effects on the cows after the abrupt changeover.

This was in contrast to earlier results when these cows were eating silage, freshly chopped alfalfa containing 20% to 24% crude protein per unit of dry matter. Dehy-100 introduced abruptly into this ration in place of soybean meal caused the cows to eat grain concentrate irregularly and to refuse large amounts after a 2-day period during which they had begun to eat the grain concentrate containing Dehy-100. The Dehy-100 did not contain a preservative at that time.

Since the silage ration already contained a quantity of nitrogen far in excess of the cow's requirements, perhaps the depressed concentrate consumption resulted because the critical physiological level for soluble NPN (all of the urea nitrogen and 30% of the alfalfa nitrogen) in the diet was exceeded. Another possible cause may have been that the ground corn and cob meal with which the Dehy-100 was combined was too moist. If so, this could cause heating and release of ammonia which would reduce palatability. In fact, the most probable cause of failure of cows to eat urea feeds is the development of free ammonia in the feeds. From the management standpoint, this is basically a problem of high moisture content of the feeds with which the urea is mixed or the result of the mixed feed absorbing moisture from humid air. The presence of moisture in the cereal grains allows for sufficient microbial

TABLE 5.—Monetary Value of Dehy-100 and Urea-Treated Corn Silage Based on the Value of Their Estimated Non-protein Net Energy (N.E.) and Digestible Protein Content. Values of Digestible Protein and Non-protein N.E. Are Based on Corn at \$55. per Ton and Soybean Meal at \$95. per Ton.*

Feed	Digestible Protein	Estimated N.E.	Non-protein N.E.	Value of Digestible Protein per Ton	Value of Non-protein N.E. per Ton	Total Value of Dig. Protein and N.E. per Ton†
	(%)	(Therms/Ton)‡	(Therms/Ton)‡	\$	\$	\$
Shelled corn	4.9	1620	1475	10.52	44.46	54.98
Soybean meal	37.4	1592	488	80.28	14.71	94.99
Dehy 100	89.5	600	361	192.10	10.88	202.98**
Corn Silage (Dough Stage)	4.1	1300	1138	8.80	34.30	43.10
Corn Silage + Urea	8.2	1300	1138	17.60	34.30	51.90

*Calculations made on air dry basis.

†Dollar value of feed when corn is \$55 per ton and soybean meal is \$95 per ton = (lb. of digestible protein per ton x \$0.10732) + (therms of non protein net energy per ton x \$0.3014). Values for digestible protein and non-protein net energy were determined from Petersen's formulas (J. Dairy Sci. 15:293, 1932) modified to use non protein N.E. for TDN. See Ohio Report, Nov.-Dec. 1968, p. 90.

‡One therm = 1 million calories.

**If 800 lb. of Dehy 100 is mixed with 1200 lb. of ground shelled corn, the resulting mixture which contains 45.4% crude protein has a dollar value as calculated in this table of \$114.20 per ton. This mixture is approximately equal in nutritive value to a ton of soybean meal worth \$95 per ton and at the prices used would cost only \$73. per ton.

activity to cause production of urease, an enzyme which splits the urea into ammonia and water. Heating of the feed usually accompanies this process. It is obvious that substituting soybean meal for urea in such cases will eliminate this particular problem.

The logical conclusion is that urea or urea-containing concentrates should be combined with dry cereal grains and protected from moist air after mixing. This is the sixth major consideration for the successful use of urea.

QUESTIONS ABOUT UREA

Among some dairymen, there is a reluctance to use urea. The following questions, which have been asked during the course of various Extension meetings in Ohio, reflect this concern about its use and limitations. It is hoped that the answers offered will provide a basis for safe decision making among dairymen concerning the use of urea.

Questions on Urea-Treated Corn Silage

How is it made? The common recommendation is to use 10 lb. of feed grade urea per ton of corn ensiled. This results in a silage containing about 2% nitrogen (13% crude protein equivalent) on a dry matter basis. Further guidelines with respect to how much urea to add with varying moisture content of the silage are presented in Table 1. The urea should be spread as evenly as possible across the top of the loaded wagon of freshly chopped corn. As it passes through the blower, it is thoroughly mixed for safe feeding. When used in a bunker silo, the corn silage-urea mix should also be run through a blower for mixing before stacking.

How much dry matter should it contain? Thirty-two percent dry matter is perhaps a minimum dry matter content of the corn silage if urea is added. At lower dry matter contents (26 to 31% dry matter), silage intake along with total feed intake is usually depressed, often as much as 20%. As the dry matter content of the silage is increased, the loss of urea as ammonia increases. At 44% dry matter in corn silage, a loss was observed of 18% of the urea nitrogen added to the silo. It is concluded that the best results with adding urea to corn silage will be obtained when the silage is 32% to 40% dry matter.

Is fertilizer grade urea as good as feed grade? The nutritive value of urea is determined by its nitrogen content and thus urea sources may be compared on that basis. However, this is not a question for the nutritionist to answer. *The user must answer this question for himself.* It becomes a question of risk and legal responsibility. Feed grade urea may be assumed to be entirely safe for feeding cattle if thoroughly mixed in grain concentrate or corn silage in amounts recommended to meet the

nitrogen requirement. Neither manufacturers nor government agencies assume responsibility for the use of fertilizer urea in feed. Risk against possible contamination is assumed entirely by the user.

How efficiently is urea-treated corn silage utilized? On a per pound basis, the silage is used about as efficiently as any other feed containing 13% crude protein. The problem is that cows usually eat less and give less milk. Results of the Ohio study are discussed on pages 4 and 5. The nitrogen in urea-treated silage is used about 94% as efficiently as nitrogen from essentially all vegetable protein supplements (Figure 1).

Are urea and nitrate toxicities additive? No. Neither urea nor nitrate toxicity are likely to occur as a result of cows eating corn silage under Ohio conditions. Urea toxicity is in fact ammonia toxicity. It is acute and results in the animal kicking at the abdomen, staggering, and perhaps death.

Nitrate poisoning is the result of nitrites being formed from nitrates. Cattle eating nitrates may have this material reduced to nitrites in the rumen. Direct absorption of nitrites into the blood stream results in the oxyhemoglobin of the red blood cells being converted to met-hemoglobin. The latter reaction is irreversible. Consequently, the oxygen-carrying capacity of the red blood cells is permanently damaged. Nitrite poisoning may be acute and cause death. Affected cows not dying usually continue to deteriorate as red blood cells are replaced slowly (on the average every 120 days).

One should be wary of a diagnosis of nitrate poisoning. Rather detailed experiments have been carried out and the results lead to the conclusion that the widespread diagnosis of off-feed conditions as "nitrate poisoning" would not likely be supported by clinical tests for significantly reduced oxyhemoglobin.

Elliot, Hogue and Loosli (10) reported data from a trial in which the nitrate and urea levels likely to be encountered in practice were simu-

TABLE 6.—Average Daily Feed Consumption and Milk Yield and Average Blood Data (10).

	Treatments			Standard Error
	Urea	Urea + Nitrate	Control	
Hay (lb)	5 0	5 0	4 9	0 04
Corn silage (lb)	47 1	53 6	51 9	2 8
Concentrate (lb)	31 0	30 6	31 4	0 3
Milk yield (lb)	57 4	61 0	60 4	2 0
Hemoglobin (mg /100 ml)	13 13	13 06	13 25	0 33
Met hemoglobin (mg /100 ml)	0 32	0 41	0 25	0 07

lated. Their results for feed intake, milk, and blood hemoglobins are shown in Table 6. The nitrate was included at the level of 0.6% of the total ration dry matter as nitrate ion. Their data, cited in Table 6, indicate that in most instances a combination of urea and nitrate in the ration of dairy cattle at the highest levels of nitrate commonly found would in no way be detrimental to feed consumption or milk production.

Finally, there is no evidence that vitamin A requirements for dairy cows are substantially affected by the presence of nitrates in the ration.

Questions on Urea in Concentrate Mixtures

How much urea may be used in a concentrate in (a) stanchion barn, (b) milking parlor? In general, urea may be used at the 2% level in the concentrate with most dairy cow rations. With Dehy-100 (see page 9), 3% urea has been added. This assumes that the cows will be fed and eat at peak lactation 30 to 36 lb. of grain concentrate daily.

The amount of concentrate containing varying levels of urea which cows will eat in a milking parlor has not been measured. Experience at the North Central Branch (Castalia) leads to the conclusion that abruptly removing the soybean meal and replacing it with urea or Dehy-100 reduces the palatability sufficiently so that additional quantities of concentrate must be fed as top dressing to forage in the bunk feeders to make up for that not consumed in the parlor.

Can urea be used in calf rations? Yes. Urea has been successfully used in both calf starters and calf-growing concentrate rations in amounts up to 4% of the total dry matter content of those rations.

Does urea cause breeding troubles? No

Can Dehy-100 be used in corn silage? In these experiments, Dehy-100 in corn silage was not more useful than an equivalent amount of urea. In both cases, milk yield was reduced below that obtained with using urea directly in the grain mix. This occurred despite the fact that 20 lb. of cereal grain was mixed with the urea-treated silage as it was fed.

Molasses-Urea Interaction

Does molasses mask the taste of urea? Yes, molasses will help mask the taste of urea. Mixing with corn silage or pelleting urea with high fiber feeds such as alfalfa meal or beet pulp also helps mask the taste of urea.

Compare liquid molasses with dry molasses. It was found that 3 to 5% dry molasses in the concentrate ration had no effect on increasing the palatability of urea containing rations. On the other hand, pelleting urea with dried molasses was a very effective way of masking the taste of urea.

Does molasses and urea form a complex? Only if heated along with the release of ammonia. This situation occurs when urea containing concentrates are processed in a moist condition or become wet after processing.

How much molasses should be used? For purposes of masking taste, 5% wet molasses appears to be satisfactory. If urea is thoroughly mixed in finely ground cereal grain, it will be used efficiently in the rumen without molasses. Dry molasses has been substituted for corn meal in high urea diets as part of a pelleted feed up to the level of 33% of the total grain and concentrate eaten. Normal feed intake, nitrogen utilization, and milk yields were obtained.

Molasses may be more important when feeds high in ammoniacal nitrogen are fed, such as urea-treated corn silage. This question has not been adequately answered experimentally.

General Questions on Urea

How much urea can be fed per head per day? Three-fourths lb. for small breeds and 1.0 lb. per head per day for large breeds. This amount should meet their nitrogen requirements. In these studies, Holstein cows have been fed an amount of urea in the form of Dehy-100 which provides much more than their nitrogen requirements. They received from 1.2 to 1.6 lb. of urea daily in 20 to 26 lb. of concentrate (6% of the concentrate), plus 20 to 26 lb. of alfalfa hay and 20 to 26 lb. of corn silage daily. They milked and ate normally and averaged 59.9 lb. of actual milk per day for the first 5½ months.

How much NPN can cows utilize per day? With labeled N¹⁵ in ammonium salts, Virtanen (22) found 26 to 40% used in the milk plus tissue. In Ohio studies (see page 9), it was estimated that 3.5 lb. of protein could be formed in the rumen of a 1400 lb. cow per day. This is 0.56 lb. of NPN or 1.2 lb. of urea.

In addition to utilizing NPN, cows must be able to physiologically process the residual NPN. Apparently some difficulty is experienced when the NPN becomes ammoniacal nitrogen in silage or in the rumen and there is not sufficient fermentable carbohydrate present to utilize it efficiently. Under these conditions, 0.4 to 0.5 lb. of NPN per 1000 lb. of body weight is all that a cow may consume (see page 5).

What is the effect of over-feeding urea? Sometimes the symptoms are mild (rapid breathing, staggered gait). However, if enough urea is eaten in a short time, the animal will die rapidly of ammonia poisoning. Death occurs when the ammonia concentration in the rumen reaches approximately 800 milligrams of ammonia per liter of rumen fluid. In practice, this may happen if a cow instantaneously consumes 0.3 to 0.6 lb. of urea without sufficient readily fermentable carbohy-

drates present so that the ammonia is used by the rumen microorganisms. From the discussion above, it is obvious that cows can consume concentrates containing 6% urea with molasses and cereal grain included without fear of toxicity.

The necessary control here is that it should be mixed well with plenty of carbohydrates (starch or sugar). This is the seventh major consideration in establishing guidelines for urea feeding.

SUMMARY

Urea is becoming an increasingly important ingredient in the ration of dairy cattle. The total annual tonnage of feed urea is approaching 500,000 tons for all classes of ruminants. Nevertheless, there have been enough failures with feeding urea to prompt skepticism among dairymen making management decisions. A few have ruled out urea as a feed ingredient for dairy cows.

In this study, a discussion is presented of experiments used in establishing guidelines for using high levels of urea in dairy cow rations. The guidelines developed were:

1. The limits of tolerance for non-protein nitrogen is 0.4 to 0.5 lb. of non-protein nitrogen per day per 1000 lb. of body weight.
2. Cows fed high urea rations should be eating 20 to 33 lb. of cereal grain daily.
3. Cows need about 2 weeks to become adapted to maximum urea utilization.
4. Cows can convert about 10% of the daily intake of digestible organic matter to microbial protein. The remainder of the protein requirement must come from the feed protein by-passing rumen degradation.
5. Pelleting urea with alfalfa will permit doubling the amount of urea which can be added to the ration of dairy cows.
6. Urea or urea-containing concentrates should be combined with dry ground cereal grains for feeding. Mixing with high moisture corn usually causes major feed refusals.
7. Urea or urea-containing concentrates should be mixed thoroughly in the grain.

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